THE ENVIRONMENTAL EVALUATION WORK GROUP FY 1979 STUDIES OF THE WINTER NAVIGATION DEMONSTRATION PROGRAM

EVALUATION OF LAKE WHITEFISH AND HERRING SPAWNING GROUNDS AS THEY MAY BE AFFECTED BY EXCESSIVE SEDIMENTATION INDUCED BY VESSEL ENTRAPMENT DUE TO THE ICE ENVIRONMENT WITHIN THE ST. MARYS RIVER SYSTEM

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A study starting in February of 1979 attempted to locate the spawning grounds of the lake whitefish, Coregonus clupeaformis, and lake herring, Coregonus artedii, and to determine the amount and classification of sediments deposited over these spawning grounds. Proportionately larger amounts of sediments were collected over those identified spawning grounds adjacent to the shipping channel as opposed to sites remote from the shipping channel. Attempts to recover eggs of the above species from the spawning ground were unsuccessful.

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PREFACE

The late award date of this contract coupled with the early destruction of the ice field on 18 March by the excessive speed of the motor vessel Cason J. Calloway made it impossible to meet all objectives as set forth in the original proposal under "Scope of Work".

The reference to coregonines in this report includes only the lake whitefish, *Coregorus clupeaformis*, and lake herring, *Coregonus artedii*, unless otherwise stated.

ACKNOWLEDGEMENTS

Sincere gratitude is extended to the following persons who helped with this project. J. Milton Watt, Edith and Marvin Watt of Neebish Island for assistance and a haven from the cold. Darrian Davis for his very able and professional help during the field work. John Gagnon of CRREL, who along with Darrian had to suffer the ignominy of being rescued by a Coast Guard helicopter. John Crowe and Rick Bertram for "scuba" assistance. Mac Freeborn of the Corps of Engineers, Sault office. Marie-France Bernier, Ontario Ministry of Natural Resources. Walt Duffy of Michigan State University. Thor Conway, Regional Archeologist, Ontario Ministry of Culture and Tourism.

ABSTRACT

The St. Marys River (connecting channel between Lake Superior and Lake Huron) has historically been associated with the harvesting of coregonines during late fall spawning. Winter navigation and its associated activities could have deleterious affects on the incubating eggs, including excessive sedimentation, localized current alterations, and dislocation of eggs due to vessel induced pore pressure response.

A study starting in February of 1979 attempted to locate the spawning grounds of the lake whitefish, *Coregonus clupeaformis*, and lake herring, *Coregonus artedii*, and to determine the amount and classification of sediments deposited over these spawning grounds. Proportionately larger amounts of sediments were collected over those identified spawning grounds adjacent to the shipping channel as opposed to sites remote from the shipping channel. Attempts to recover eggs of the above species from the spawning ground were unsuccessful.

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INTRODUCTION

Information dating back to the early 1900's (MacDonald, 1977) and as late as 1978 (Charles MacLeod, personal communication) indicates that lake whitefish, Coregonus clupeaformis, and the lake herring, Coregonus artedii, spawn in the lower St. Marys River. Some of these grounds are confined to the southern portions of Lake Nicolet and the northern portions of Lake Munuscong (see Figure 1).

Both of these fish are known to spawn in late October, November and early December (Machniak, 1975; Scott and Crossman, 1973), with an incubation period for whitefish in the northern Great Lakes requiring about 168 days (Faber, 1970), and about 2 weeks less for the lake herring or 154 days. This incubation period occurs partly during the extended navigation season on the St. Marys River, which usually runs from about the first of January to the middle of April. Whitefish spawning normally takes place over gravel and/or rubble bottoms in depths ranging from 1 to 5 meters but other substrates and depths may be used (Machniak, 1975). The eggs are slightly more dense than water and are randomly scattered over the bottom (Hart, 1930).

In addition to these species the round whitefish or menominee, Prosopium cylindraceum, and the burbot, Lota lota, may utilize the same spawning habitat at nearly the same time since they have very similar spawning requirements to those of the whitefish and herring (Normandeau, 1969; Scott and Crossman, 1973).

Vessels traversing the ice fields during extended navigation may

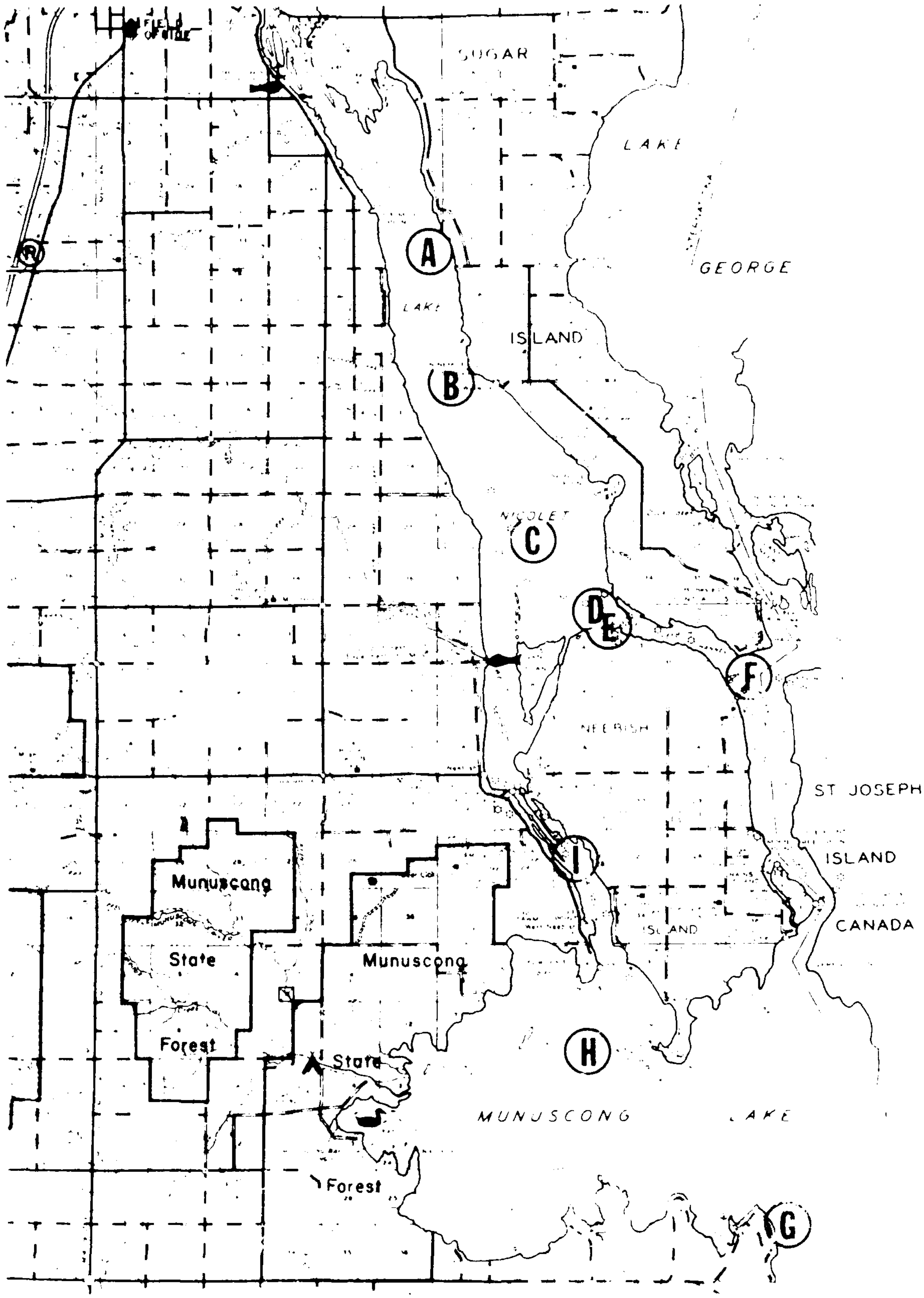


Figure 1: A map of the research area showing reported spawning sites.

encounter such resistance as to be under full power with no forward movement. The distance between the ship's propeller and the channel bottom for ships traveling in the St Marys system will usually be slightly over 1 meter when laden with cargo and may be considerable less during vessel entrapment due to "squat". Entrapment can be compared to hydraulic dredging, and this, added to the normal current velocities within the system may be sufficient to resuspend large amounts of sediment and allow them to be redistributed downstream.

Two of the tentatively identified spawning sites in the southern Lake Nicolet area are directly downriver from areas known to be frequent points of vessel entrapment. Ice breaking activities in conjunction with the efforts by entrapped vessels to free themselves have produced considerable turbidity extending as much as 1 to 1½ miles downriver from the point of vessel entrapment. High turbidity in this area was found to be a factor in influencing winter recreation (ice fishing) during extended navigation (Gleason and Behmer, 1975).

There is a substantial amount of literature describing the effects of turbidity and suspended sediment on the aquatic community (Everhart and Durchrow, 1970). Peters (1967) summarizes:

> "The influences of inorganic sediment on aquatic life in streams were summarized recently by Cordone and Kelley (1961). They pointed out that there is abundant qualitative evidence that sediment is detrimental to aquatic life in salmon and trout streams. Historical changes in aquatic populations in warm water streams resulting from sedimentation have been reported by Ellis (1931), Trautman (1957) and Lar[illegible]

and Smith (1963). The question, "How much sediment is harmful?" has not been answered for either trout or warm water streams, since most workers failed to measure the amounts of sediment."

Trautman (1957) states, in reference to the lake whitefish:

"Until 1890 whitefish spawned in the Detroit River and Maumee Bay. After 1890 a sharp decrease in the size of the Detroit River Run occurred; by 1900 the run had apparently stopped entirely. About 1900 the ever increasing silt load of the Maumee River began smothering the Maumee Bay spawning areas, causing the annual take in Maumee Bay to decline until by 1918 only 10-20 whitefish were taken daily... This decline has continued, and since 1940 only an occasional stray has been taken."

Machniak (1975) states:

"Turbidity at natural levels is generally not harmful to fish but abundant amounts of suspended sediment may have detrimental effects. Eggs and fry are more susceptible to harm by high turbidities might smother whitefish eggs in silt. Also, Hartman (1973) stated that 'whitefish require relatively silt-free areas for successful reproduction...'

Van Oosten and Hile (1949) and Van Oosten (1948), however, showed that no clear-cut relationship exists between turbidity and the success of reproduction in whitefish...

Christie (1963) suggested turbidity and siltation as one of the important factors which limit spawning facilities and reduce [illegible]

of deposited eggs. Anderson and Smith (1971) showed that _Coregonus spp_. eggs in Lake Superior were more abundant and viable in areas which had a low percentage of silt and organic matter."

Machniak further states that:

"High silt deposition occurring on lake whitefish spawning grounds will probably be detrimental to developing embryos, as has been demonstrated for pike (_Esox lucius_) spawning in reservoirs (Hassler, 1970). Zawisza and Backiel (1970), however, found that sedimentation was not a significant factor in egg mortality of _Coregonus albula_. Unfortunately, no studies have been done in this area and it is unknown what amounts of silt cause egg mortality or how mortality might vary at what stage of development the eggs are covered..."

Peters (1967), carried out a study on the sedimentation rates, stream discharge and water temperature of Bluewater Creek, Montana. He constructed manmade redds near five sampling stations and placed eyed rainbow trout, _Salmo gairdneri_, eggs in Vibert boxes on these redds. His results show a progressive increase in mortality, 3% to 70%, with an increase in median monthly suspended sediment concentrations, 18-186 ppm, except at his last station where current velocities did not allow sediment deposition. Mortality at that station was 47% with sediment concentrations at 310 ppm. He felt that some of the mortality experienced may have been due to increased stream temperature that accompanied the increased sediment load.

There are other aspects of whitefish ecology that should be noted because they could have affected the results of this study.

Coregonid eggs normally suffer high mortality rates, Machniak (1975) summerizes "Undoubtedly a large mortality occurs in lake whitefish eggs... However, the lack of good quantitative data makes it impossible to estimate the proportion of eggs surviving to hatching." Besides potential environmental problems, predation by fishes is important in reducing egg numbers (Machniak, 1975) in addition the amount of dissolved oxygen and carbon dioxide may have an effect (Hall, 1925). Machniak (1975) further states "Bajkov (1930) speculated that the mortality of fertilized eggs and fry, under natural conditions, is very great, perhaps somewhere about 99%... Hart (1930) estimated mortality of developing eggs on the spawning grounds to be from 50-80% with the combined mortality of egg predation exceeding 90%."

Whitefish are known to migrate from deeper water to the spawning areas as the water temperature drops in the fall (Hart, 1930). This is especially true for river spawners (Machniak, 1975). Whether whitefish home to certain areas to spawn is unclear. Christie (1973) and Budd (1957) suggest this may be true for certain populations. Machniak (1975) states "The destruction of preferred spawning habitats could be especially serious if lake whitefish "home" to such areas... This would ultimately result in the demise of a particular stock of fish."

It is interesting to note that the Ontario Ministry of Natural Resources had difficulties in pinpointing whitefish spawning bed locations in the upper St. Marys River. They employed a commercial fisherman to gill net in the area between Leighs and Marks Bays near the source of the river. The fisherman was able to recover over 2000 fish, in spawning condition, between 20 October and 9 November, 1978 (Wholgemuth, 1978). This area was classed a.

a "highly important spawning ground" (Wohlgemuth, 1978).

Subsequent efforst (27 February to 13 March, 1979) to locate the exact spawning site in the Leighs Bay area through the use of a pump and eckman dredge yielded one coregonine egg (Rosa, 1979).

It has become evident, based on the above, that definitive means of delineating the size and importance of spawning grounds must be measured through the use of spawn traps during spawning.

OBJECTIVES

1. To identify and map spawning grounds with verification at the various study sites through the collection of eggs.
2. To determine the species composition of the spawning grounds (i.e. are they entirely whitefish, herring, or a combination of the two).
3. To determine the amount of sediment being deposited on the grounds as a result of extended navigation. This will be done:
   a. During periods when the river is free of vessel passages.
   b. During periods when ice breaking activities are being carried out.
   c. During periods when the river is free of ice.
4. To quantify and analyze the sediments being deposited over the identified spawning areas. This will include:
   a. Determination of the amount of organic and inorganic materials in the sediment.
   b. Determining the biological oxygen demand of the sediment.
   c. Determining settling rates of sediments.

METHODOLOGY

Spawning beds were identified through interviews with local fishermen. Records of the Michigan Department of Natural Resources, U.S. Fish and Wildlife Service and the Ontario Ministry of Natural Resources were of no help in locating spawning areas in the lower river.

Some of the reported spawning grounds were checked by pumping sediments through the ice by the use of a 3 h.p., 1½" gasoline powered "trash" pump to try to collect live eggs to verify spawning and to try to delineate the extent of the spawning ground. Figures 2 and 3 show the use of the pump at one of the "Rock Cut" stations (see discussion below). The pump was discharged into a wash bucket with 80 mesh bottom screen. Recovered material was searched through with the aid of a dissecting microscope, the invertebrates and small fish were removed and preserved in 70% alcohol.

After spring ice breakup "scuba" divers were used in a continuing effort to locate spawning ground. About 15 hours was spent by the divers in an underwater search of reported areas. The divers searched likely areas looking for eggs and also directed the intake of the pump deep into areas where eggs might have settled. Bottom sediments were also stirred up and pumped up for examination. For pumping operations from a boat a conical discharge net was constructed of the same mesh material mentioned earlier. Sediments were retrieved from a small cup at the end of the net.

Sediment samplers were placed near reported sites. These submerged samplers were similar to those designed by Gleason (1961), (see Figure 4). The samplers were constructed by mounting a number 1 (soup) can to the surface of 30.5 cm square (1 ft.^{2}) piece of 1.9 cm (3/4") exterior grade

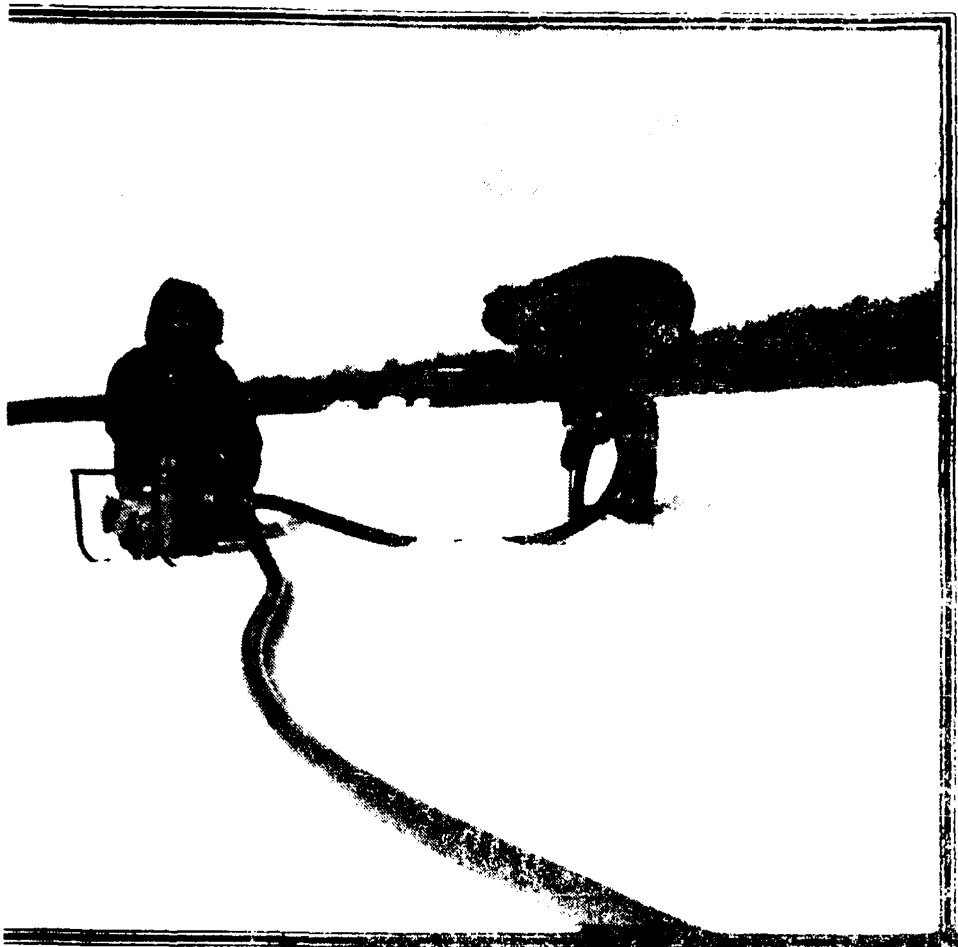


Figure 2a: Pumping for spawn in the lower St. Mary's River. Winter 78-79.

Figure 2b: Steel conduit is fixed to 7.3 m (24 ft.) flexible hose, to guide suction nozzel into interstitial space on rubble bottom.

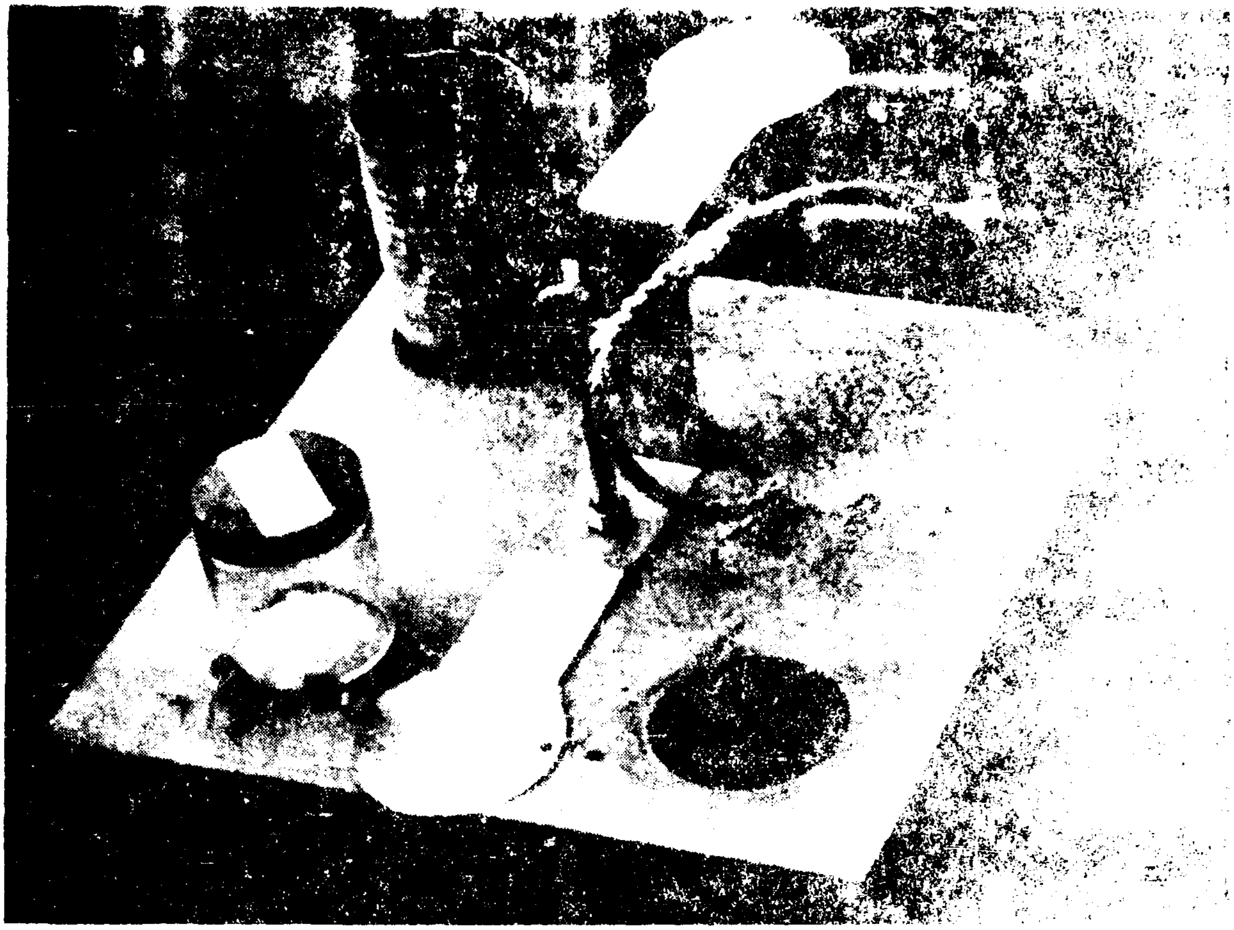
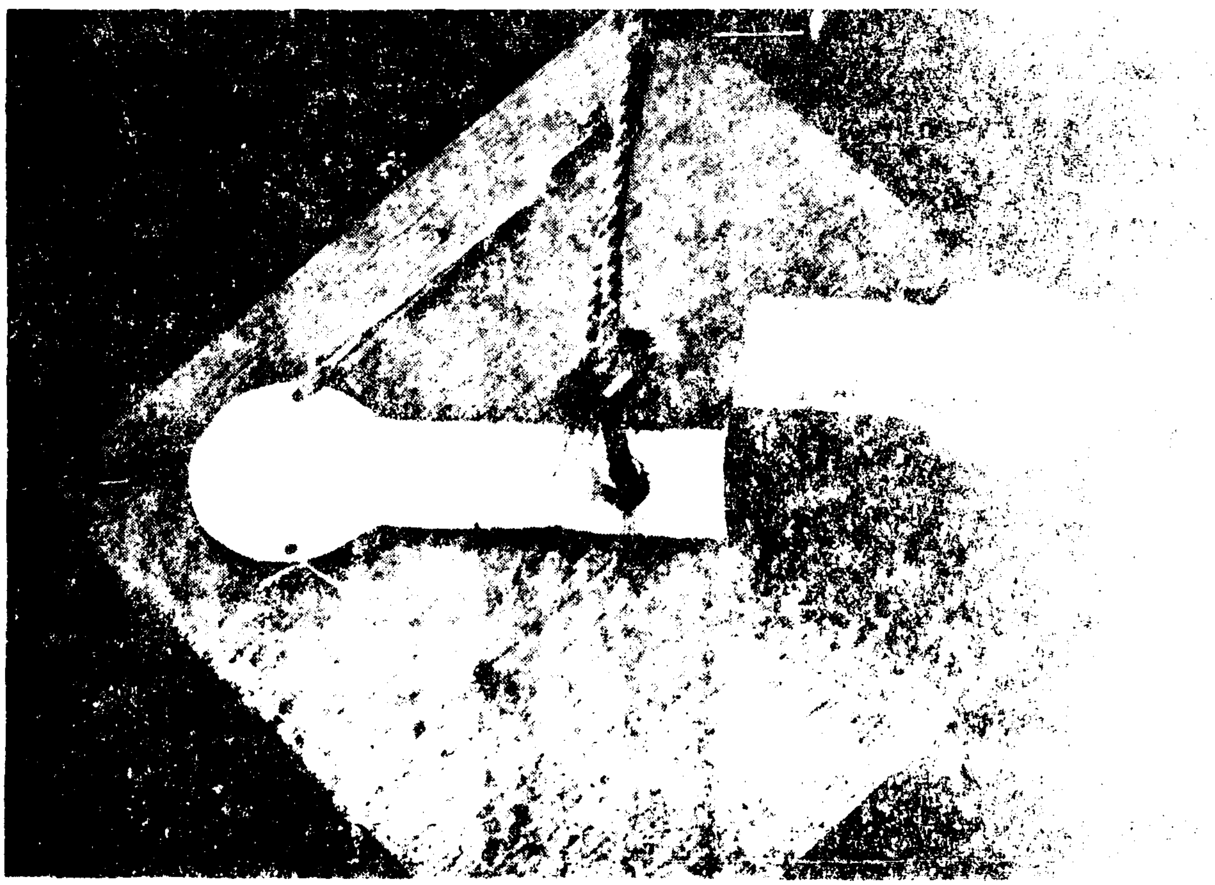


Figure 4a Sediment sampler showing high and low collectors with [illegible]



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plywood. Diagonally from the first can a second was mounted in a hole so its surface was just flush with the surface of the board. A 95 mm (3/8") x 10.1 cm (4") eyebolt was mounted through a hole in the center of the board. It served to secure a brick, for weight, to the underside of the sampler, and also as an attachment for a retrieval line. A cover of 16 gauge galvanized steel was fashioned so that it pivoted on the center bolt and through attachment to the retrieval line was used to cover the sampling chanbers when the sampler was suspended from the retrieval rope during lowering or raising. A rubber band, attached to the cover, pulled it back when there was slack in the retrieval line opening the cover. Glass jars (Ann Arbor Biological Center, Inc. #576614) were inserted in the cans for the collection of sediment. The jars have a 18.47 cm^2 mouth.

The apparatus was set up to collect sediment over a period of time. The retrieval of the samples was dependent on vessel passage, weather, and ice conditions. Sediment samples were subjected to gravimetric procedures to determine organic and inorganic content (American Public Health Association, 1975, Section 108, Residue).

SPAWNING GROUND IDENTIFICATION

Interviews with local fishermen were conducted from 1 February to 16 February, 1979. A total of 9 people were interviewed. Each informant possessed enough knowledge of whitefish and whitefish spawning habitats to convince the investigator that they were knowledgeable about the subject. Sites were reported by more than one informant, except where noted.

Descriptions of the various spawning ground locations from each of the informants were remarkably similar. Figure 1 shows the locations of nine reported spawning grounds (A-I). Each will be discussed below:

(A) Informants reported that whitefish spawn in suitable spots all along the west shore of Sugar Island from Baie de Wasai south to Shingle Bay. It was reported that there was one large spawning concentrantion and numerous small spots over much of this area (see Figure 1, Location A).

(B) Nine Mile Point - A large spawning bed was reported to be in the vicinity of the small rocky islands north of Nine Mile Point off "Camp Baraga". A lack of equipment and accessibility precluded investigation of this and several other areas during the winter of 1979. (See Figure 5, Location B).

(C) It was suggested by one informant that there may be spawning in the northern part of the "triangle" formed off the north end of Neebish Island by the intersection of the upbound and downbound channels, near buoy 52 of the downbound channel (see Figure 6, Location C). Since only one informant suggested this site, it should probably be regarded as a less important site.

(D) A large spawning site is believed to exist in the area between Shingle Bay and the southeast corner of Sugar Island. This area was investigated on 5 May with the aid of divers. The only apparent suitable spawning habitat discovered was at the southeast corner of Sugar Island (see Figure 7, Location D). Four different sites in this area, each about 28 m^2 were thoroughly

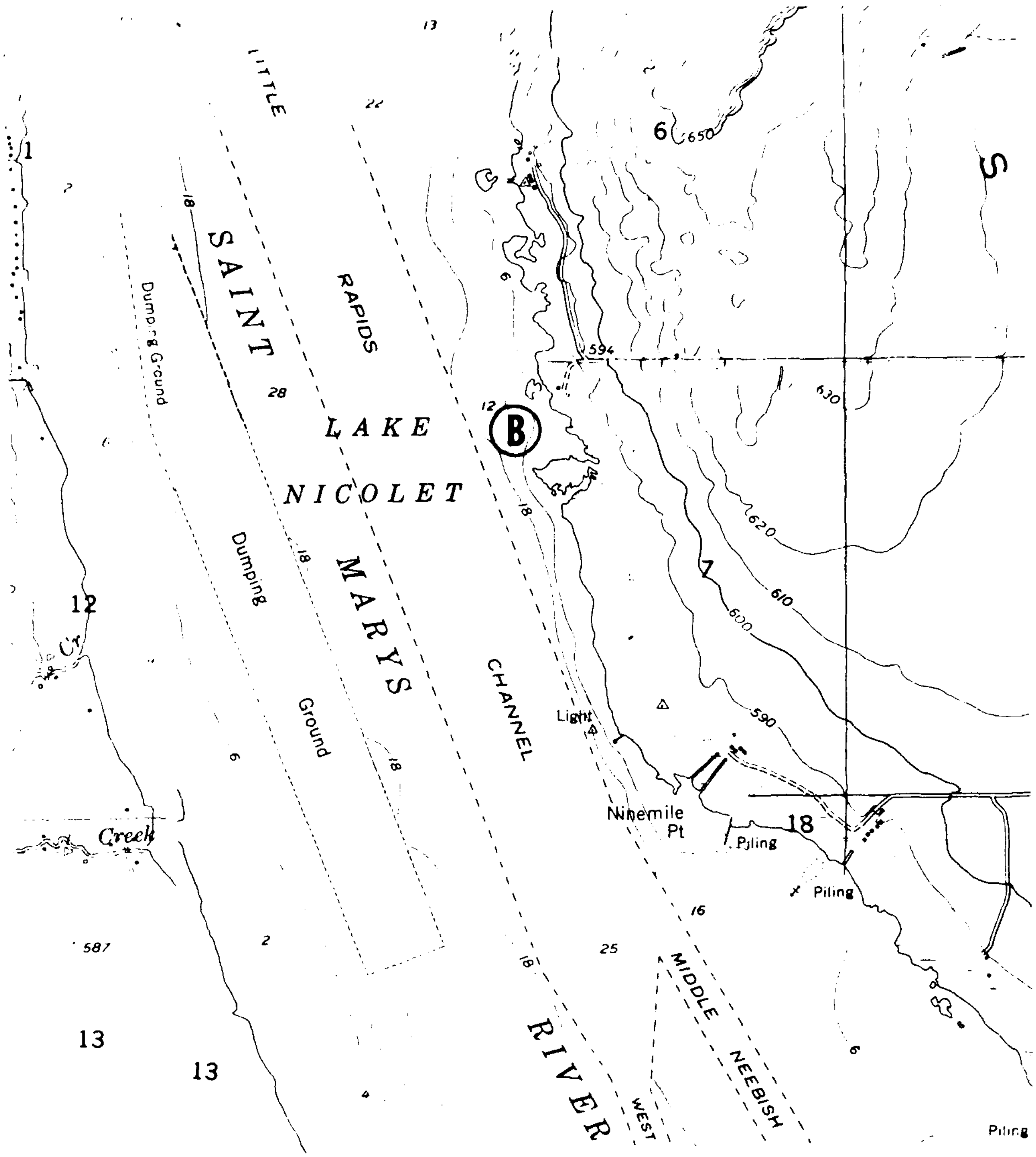


Figure 5: Map of reported spawning site north of Nine Mile Point (B, NW¼ Sec. 7 T.46N. - R.2E.).

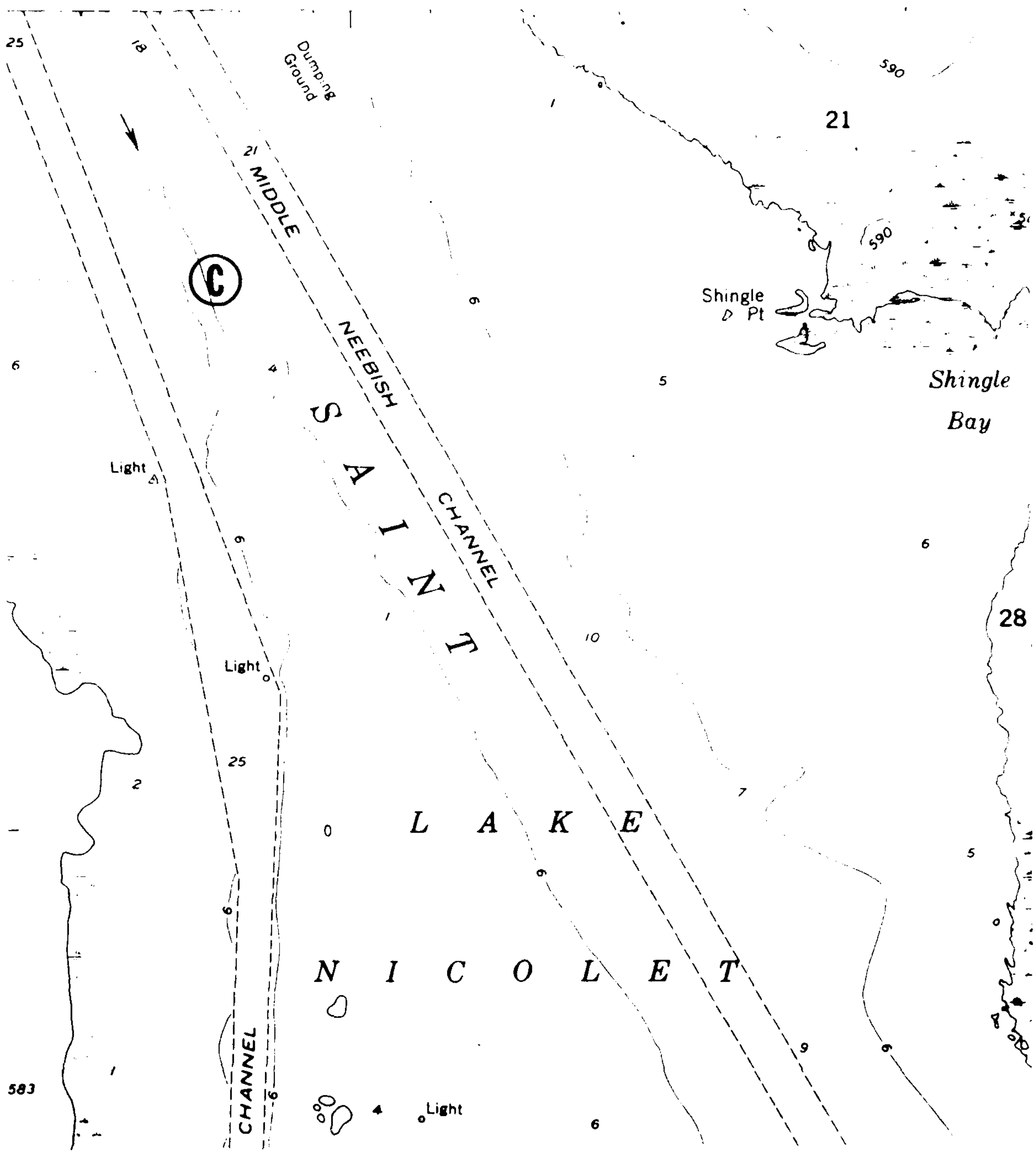
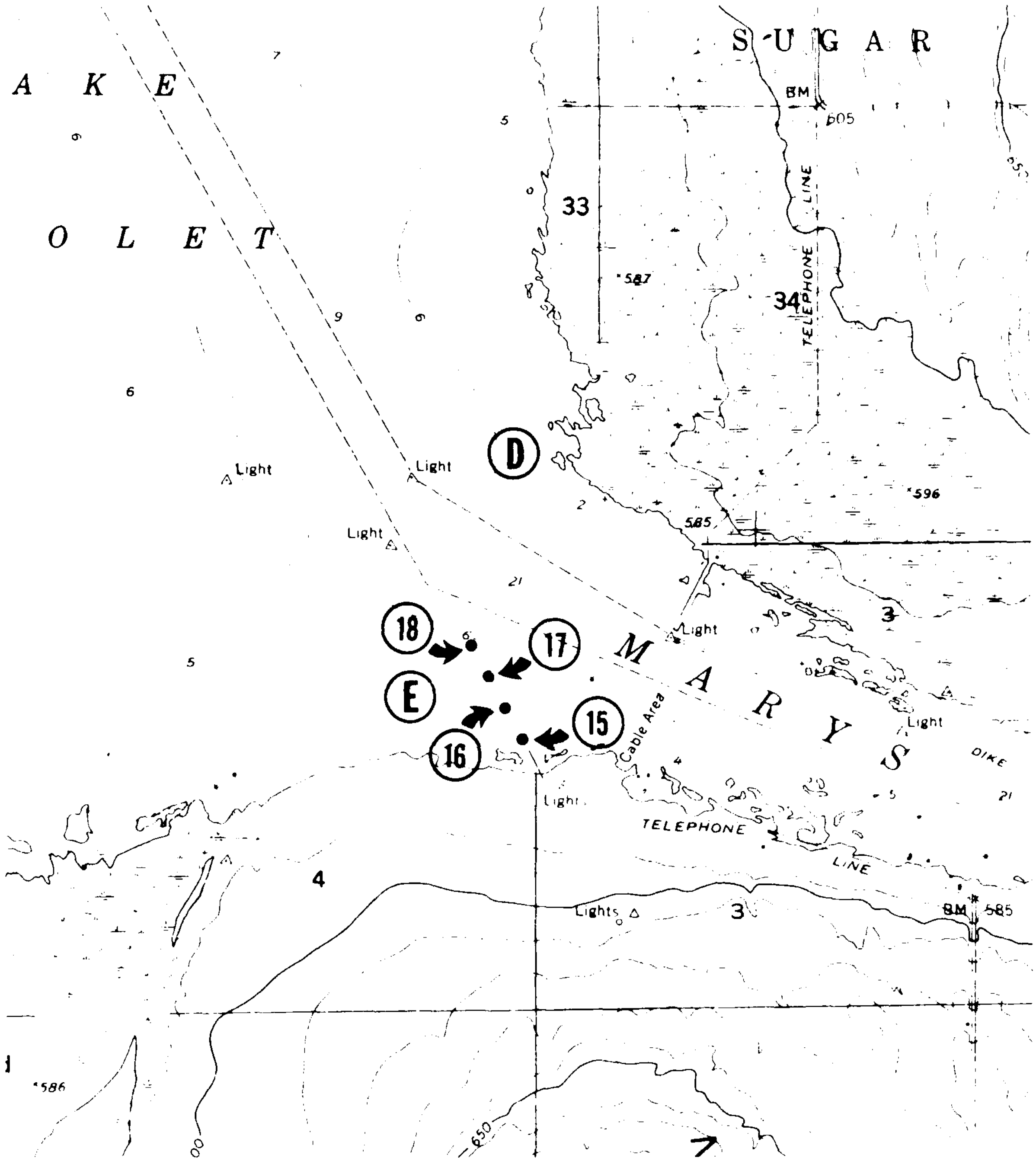


Figure 6: Map of the reported spawning site in the "triangle" area north of Neebish Island (SW½ Sec.20 T.46N. - R.2E).



Station Number	Depth of Water	Bottom Type	Number of Samples	Sampler Recovery
E-15	1.5	Muck	4	Recovered
E-16	1.5	Muck	4	Recovered
E-17	2.5	Muck	4	Lost
E-18	2.0	Muck	3	Recovered

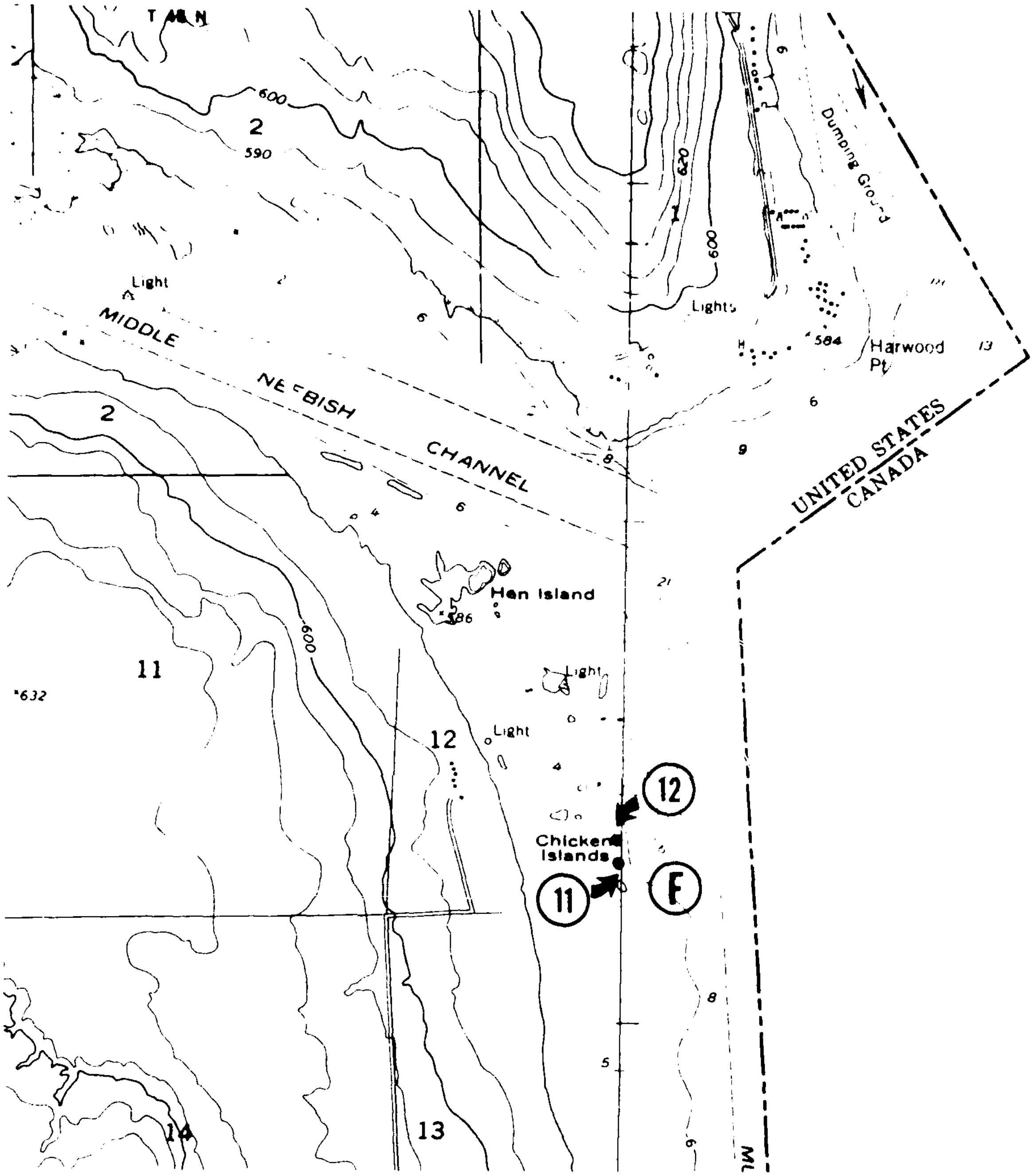
Figure 7: A map of potential spawning sites (D,E) and sampling sites (E-15 to E-18) at the north end of Neebish Island (SW¼ Sec.34 T.46. R.-2 E. and NW¼ Sec. T.45N.- R.2E).

searched by pumping by the divers. No coregonine eggs were found as a result of searching these areas. However, eggs smaller than coregonine were encountered. These were probably burbot. This area may be an active whitefish spawning site, but pumping failed to verify it.

(E) The habitat mentioned above seems to extend across the channel to the water adjacent to Neebish Island (see Figure 7, Location E). It seems likely that this area too may be potential spawning habitat, although no informant mentioned this possibility.

(F) The area along the northeast corner of Neebish Island just east of Hen Island was mentioned as a possible spawning site (see Figure 8, Location F). Extensive surveying of this area through the ice yielded no coregonine eggs. The only apparent suitable habitat was found near the largest "Chicken" island. U.S. Army Corps of Engineers aerial photographs, reviewed after spring breakup, revealed potential sites in the area north and west of Hen Island.

(G) On 12 March, 1979, Walt Duffy of Michigan State University collected several eyed coregonine eggs in ponar dredge samples off the eastern shore of Rocky Point (see Figure 9, Location G). The eggs were encountered on a hard sand bottom in about 2 meters of water. This type of habitat is used less frequently for spawning by whitefish than gravel or rocks (Machniak, 1975). These eggs may have drifted from preferred habitat or they may have been spawned in the area.



Station Number	Depth of Water	Bottom Type	Number of Samples	Sampler Recovery
F-11	2 m	Muck	4	Lost
F-12	2 m	Muck	4	Lost

Figure 8: A map of the reported spawning site in the Hen and Chicken Islands area and sampling sites (F-11, F12) (SE¼ Sec. 12 T.45N.-R.2E)

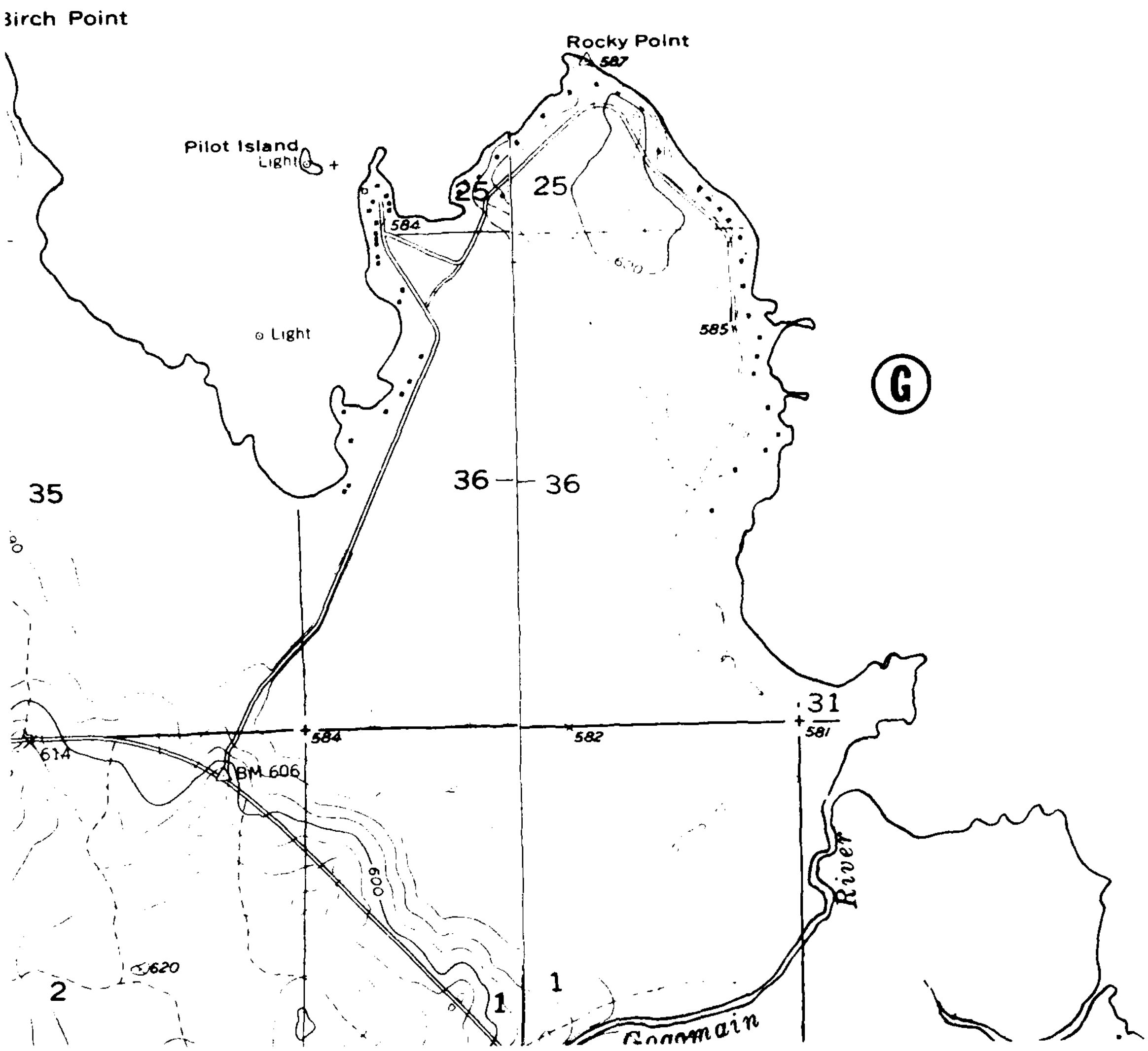


Figure 9: Map of area off Rocky Point in Munuscong Bay (G) where eyed whitefish eggs were found on March 12, 1979.
(SE¼ Sec. 25 T.44N. - R.2E)

(H) One informant suggested that there may be a spawning site in Munuscong Bay along a line from Roach Point to Conely's Point lying adjacent to the Moon Islands (see Figure 10, Location H).

(I) A major spawning site was reported to be adjacent to Neebish Island just downriver of the south dike of the "Rock Cut" (see Figure 11, Location I). This area is near, or perhaps on a dredge site that was established in the early 1960's. This area was investigated by pumping through the ice and with the aid of divers. No coregonine eggs were recovered.

CONCLUSIONS

Very little can be said of the spawning coregonine population around Neebish Island. The difficulty in recovering eggs and thereby denoting the spawning area and species composition may have been due to one or a combination of factors. The population may have been initially low. High predation rates and dislocation by currents may have reduced egg numbers to such a point that recovery was unprobable. Further spawning may be restricted to such a small area that could be easily missed. Eggs in the vicinity of the navigation channel may have been subjected to resuspension by pressure waves generated by passing vessels (Gleason et. al., 1979) which might tend to increase predation and dislocation by currents.

It is obvious from the above that it is necessary to recover eggs as soon after spawning as possible to accurately assess spawning site locations and species composition.

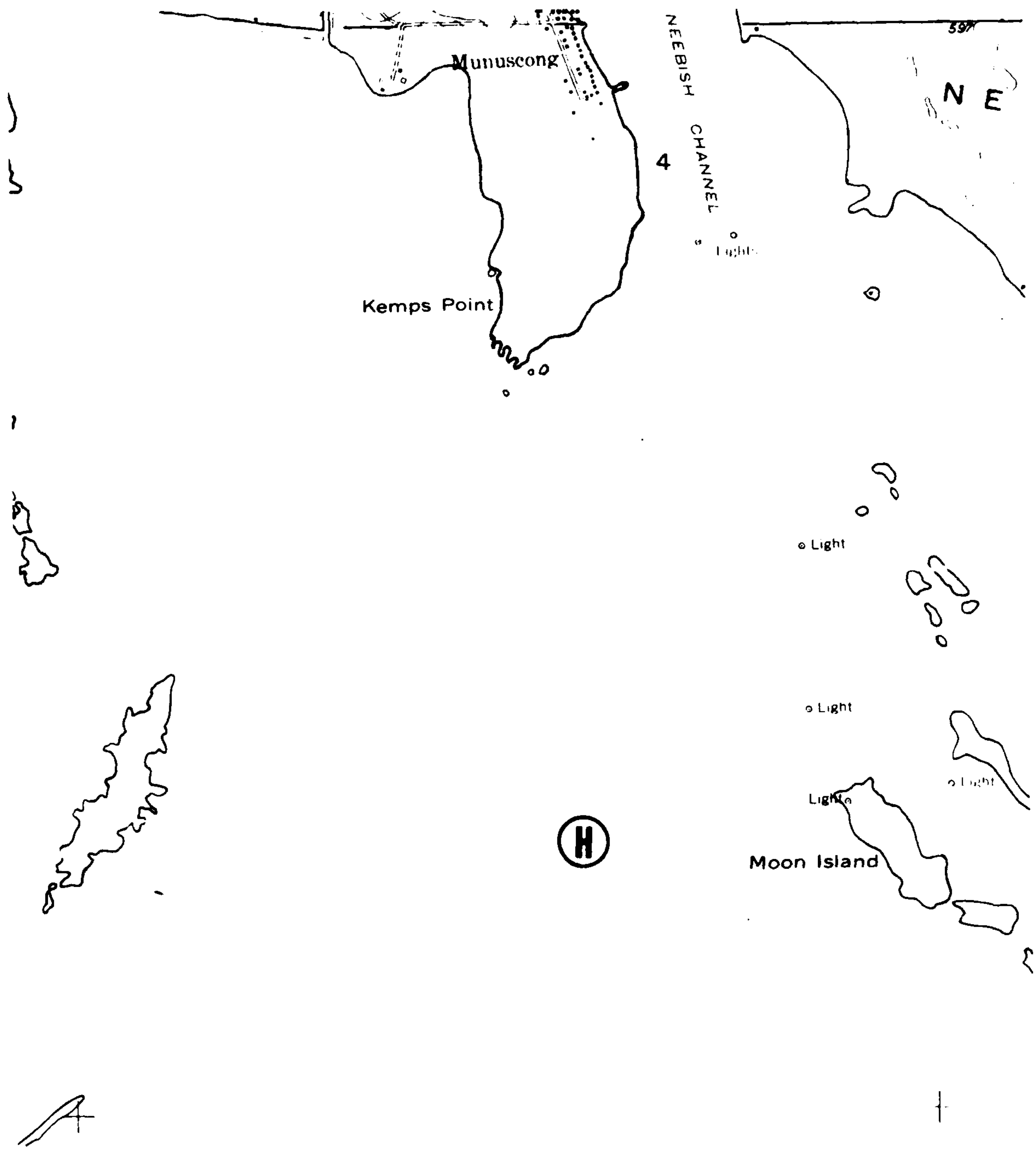
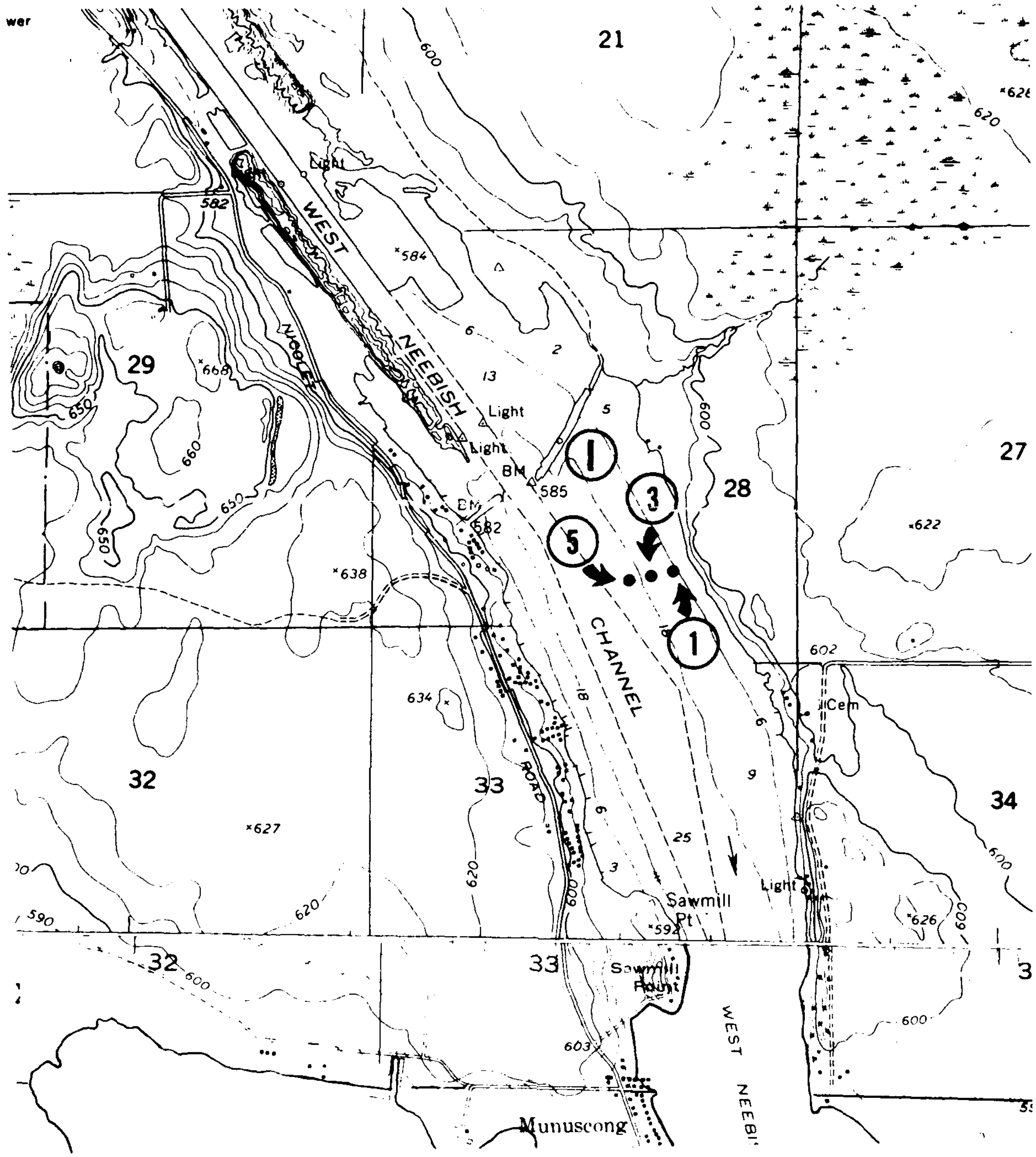


Figure 10. Map of reported location of whitefish spawning in Munuscong Bay (H, SE¼ Sec. 9 T.44N. - R.2E)



Station Number	Depth of Water	Bottom Type	Number of Samples	Sampler Recovery
I-1	3.75 m	Muck/ Stones	6	Recovered
I-3	3.2 m	Rocks/ Gravel	2	Lost
I-5	5.0 m	Rocks/ Gravel	4	Lost

Figure 11: A map of the reported spawning site in the "Rock Cut" area (I) and sampling sites (SE¼ Sec. 28 T.45N. - R2E.).

RECOMMENDATIONS

This study should be continued in late summer of 1979. Below is a list of recommendations.

(1) Inventory of all potential spawning sites described earlier should be marked with buoys and with sightings from fixed points taken to facilitate relocation. An underwater buoy that can be located with the aid of a sonic depth finder may be advantageous. This would be less likely to be disturbed by fishermen and would not be subject to removal by ice movement.

(2) Nets should be set on potential spawning sites to record fish entering the spawning areas (late October to the end of November).

(3) Pumping should take place during spawning to document species composition of spawned eggs.

(4) Laboratory and on site studies should be conducted concurrently to determine the effect of sediment on egg mortality. This should include both short and long term effects and the effects of sediment at different stages of egg development. Concurrent field studies would determine the effects of sediments on eggs under natural conditions.

SEDIMENT ANALYSIS

Nine sediment samplers were placed in three locations around Neebish

Island. It was decided, for research purposes, that three of the nine reported spawning areas would be used as sites for sediment collection and analysis. The criteria for selection was dependant upon several factors.

(1) That all sites be readily accessible by a snowmobile either overland or on the ice.

(2) That a control area be incorporated as one of the three sites.

(3) That the remaining two be in areas known in the past for their difficulty for vessel movement and immediately adjacent to the reported spawning sites.

The "Rock Cut" area was selected because it was reported as a major spawning ground and in a location closed to vessel traffic during the extended navigation season. The second site, herinafter referred to as the "North End" site, was selected because it is immediately downriver of course angle turn between 5 and 6. It was expected that this area would receive maximum sediment deposition during the project. The third site, hereinafter referred to as "Hen and Chicken" area, was selected because it was immediately adjacent and parallel to the navigation channel at a point at which vessel traffic, in the past, had had a great deal of difficulty in navigating the Stribling Point turn.

Three samplers were placed south of the "Rock Cut" (see Figure 11, I-1, I-1, I-3). They were placed roughly perpendicular to the navigation channel starting about 75 meters from shore and at about 75 meter intervals to within about 50 meters of the channel. Figure 11 shows the location of

these sites along with water depth, bottom type, number of samples from each site and the eventual fate of the sampler. Two samplers were placed on Hen and Chicken Island location (see Figure 8, F-11, F-12). These sites were roughly parallel to the navigation channel and about 400 meters west. The last four samplers were placed in a direct line with the downbound navigation channel range markers on Neebish beginning about 150 meters from shore and at about 100 meter intervals.

Data were collected between 7 March and 27 March, at which time the ice became unsafe. Four samplers were recovered during the first week in May, after the ice was out. The remaining five samplers were lost. Of the four samplers recovered in May, two had usuable samples and two had overturned by currents or ice.

Table 1 shows the analysis of data collected during this project. Included in this table are the station number, sampling period, length of sampling period, high or low collector, weight of sediment collected, percent organic and inorganic material in each sample as determined by gravimetric analysis, the average amount of sediment collected per day and the number of commercial vessel passages during the sampling period.

Two problems were encountered during analysis that should be noted. (1) Several of the samples were inadvertantly frozen in a malfunctioning refrigerator; these were kept frozen until analysis. These samples may have had small amounts of broken glass added to the sample which was removed when noticed. (2) Some of the organic/inorganic determinations may not be entirely accurate due to problems with ignition temperatures.

Table 1: Analysis of Sediments

STATION NUMBER	SAMPLING PERIOD	LENGTH OF SAMPLING PERIOD	COLLECTOR	WEIGHT OF SEDIMENT COLLECTED (In Milligrams)	PERCENT ORGANIC	PERCENT INORGANIC	WEIGHT OF SEDIMENT COLLECTED PER DAY (In Milligrams)	NUMBER OF VESSEL PASSAGES DURING SAMPLING PERIOD
I-1	3-7 to 3-18	11	High	8.7	55.1	44.9	0.79	8
I-1	3-7 to 3-18	11	Low	11.3	40.0	60.0	1.0	8
I-1	3-18 to 3-27	9	High	9.3	9.7	90.3	1.0	15
I-1	3-18 to 3-27	9	Low	17.8	20.2	79.8	2.0	15
I-1	3-27 to 5-1	35	Low	384.5	5.2	94.8	11.0	*
I-3	3-11 to 3-18	7	Low	9.7	8.2	9.8	1.4	5
I-3	3-18 to 3-27	9	High	33.3	13.5	86.5	3.70	15
I-3	3-18 to 3-27	9	Low	10.4	29.8	70.2	1.20	15
I-5**	3-7 to 3-18	11	High	3.5	65.7	34.3	0.32	8
I-5**	3-7 to 3-18	11	Low	8.2	31.7	68.3	0.74	8
I-5	3-18 to 3-27	9	High	10.6	23.6	76.4	1.18	15
I-5	3-18 to 3-27	9	Low	12.7	22.8	77.2	1.41	15
F-11**	3-12 to 3-20	8	Low	17.2	8.1	91.9	2.5	7
F-11**	3-20 to 3-27	7	Low	27.8	7.9	92.1	3.97	15
F-12**	3-12 to 3-20	8	Low	34.0	8.8	91.2	4.25	7
F-12	3-20 to 3-27	7	Low	30.7	9.4	90.6	4.40	15
E-15**	3-13 to 3-18	5	Low	13.1	7.6	92.4	2.62	4
E-15**	3-18 to 3-27	9	High	37.5	6.9	93.1	4.2	15
E-15	3-27 to 5-10	45	Low	3365.7	3.2	96.8	74.8	*
E-16	3-13 to 3-18	5	High	12.3	33.3	66.7	2.46	4
E-16	3-13 to 3-18	5	Low	12.6	27.0	73.0	2.52	4
E-16	3-18 to 3-27	9	Low	84.0	5.9	94.1	9.30	15
E-17	3-13 to 3-18	5	High	13.1	11.5	88.5	2.62	4
E-17	3-13 to 3-18	5	Low	15.2	22.4	77.6	3.04	4
E-17	3-18 to 3-27	9	High	113.5	5.8	94.2	12.6	15
E-18	3-13 to 3-18	5	High	21.4	15.4	84.6	4.28	4
E-18**	3-13 to 3-18	5	Low	16.6	15.1	84.9	3.32	4
E-18	3-18 to 3-27	9	Low	465.3	0.9	99.1	51.7	15

*Part of this sampling period was during an ice free period.

**Frozen

Figure 12 shows a plot of the weight of sediments collected per day vs. the number of vessels passing the sampling points during the sampling period (see Appendix I), for the "Rock Cut" stations. As can be seen, there is an increase in the amount of sediment collected with an increase in vessel traffic, although this trend is somewhat obscured by the large variation in amounts of sediment collected by each sampler and adjacent samplers during the sampling period. This may have been caused by the sampler orientation with respect to current. The average for these stations is 1.34 mg per day. The "Rock Cut" samplers had the highest organic content, the average for 12 samples was slightly more than 27%.

Figure 13 shows the same relationship for the Hen and Chicken Island stations. There does not seem to be any relationship between sediment collected and vessel traffic. This suggests that there may be a "background" level of suspended sediment in the river that may be held in suspension for long periods by turbulence. It is interesting to note that this rate of deposition, averaging 3.78 mg/day, is higher than the rate received at the "Rock Cut" stations. They may be somewhat "sheltered" or the bulk of the sediment may be confined to the navigation channel in use. The organic content from these stations average 8.5%, the lowest of the three areas.

Figure 14 shows the relation for the "north end" station. These stations, being in direct line with the channel, received a great deal of sediment, averaging 11.11 mg/day. Station 18, during the 3-18 to 3-27 sampling period, received almost five times more than the other stations.

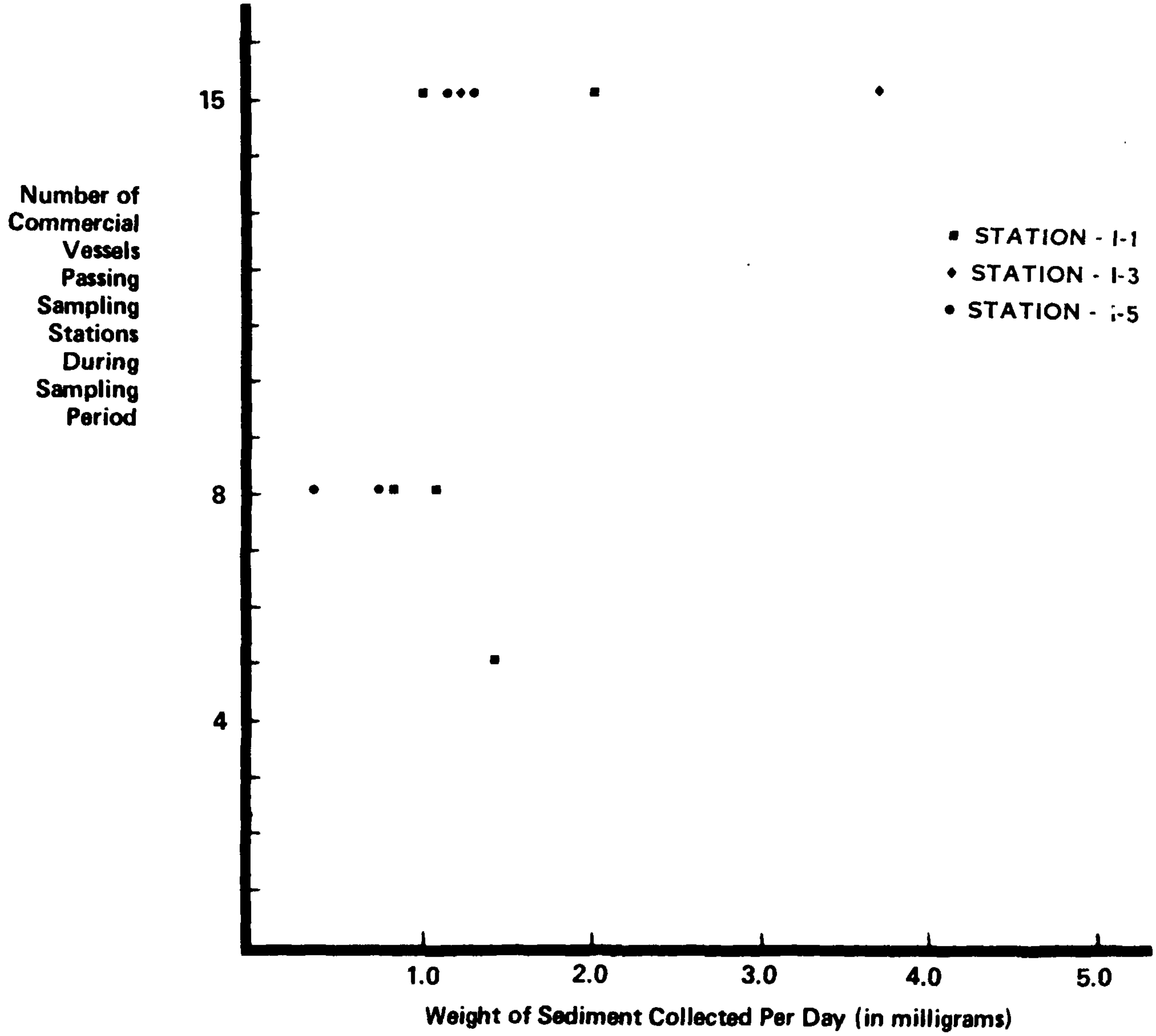


Figure 12: Rate of deposition vs. vessel traffic for Rock Cut stations.

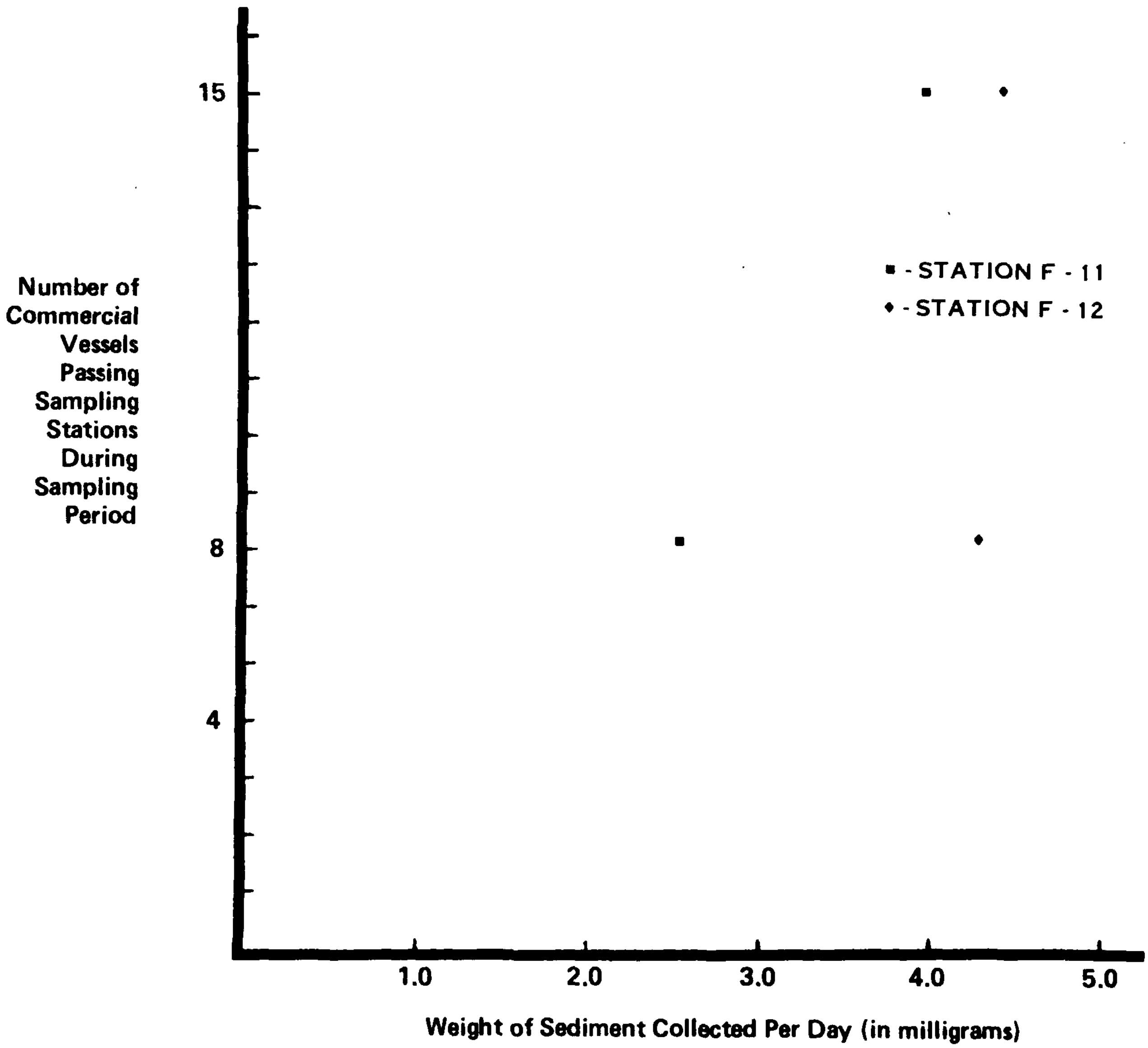


Figure 13: Rate of deposition vs. vessel traffic for Hen and Chicken stations

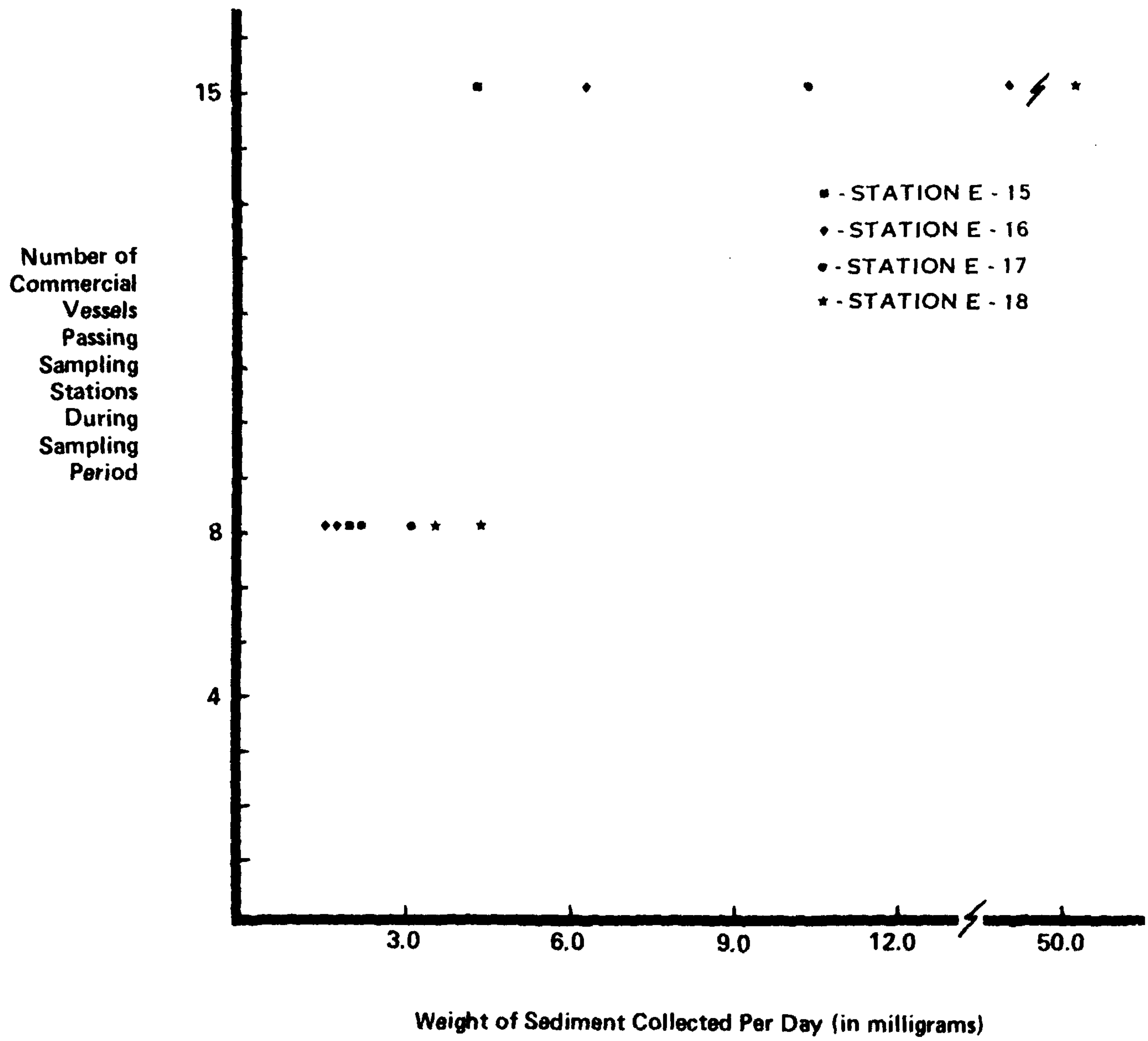


Figure 14: Rate of deposition vs. vessel traffic for North End stations

The bulk of the sediment settled out before reaching station 17, a distance of 100 meters. This shows that areas adjacent to the navigation channel can receive large amounts of sediment but that a large portion (on the order of 75% in this instance) settles quickly. Organic content of the "north end" stations averaged 13.4%.

Samplers I-1 and E-15 were in the water 35 and 45 days respectively. This was during the period of normal spring breakup on the river. The amount of sediment collected per day during this period of increased natural sedimentation was almost 3 times the greatest amount collected during the winter at station I-1 and nearly half again as much collected at station 18 during the period from 3-18 to 3-17. It appears that normal river sediments in the spring contribute to a high amount of sediment during the relatively short spring breakup.

BOD analysis was not performed due to the small number of samples available and because of the low organic content of the sediment samples which, along with river O_2 levels at near saturation level, would rapidly mineralize most deposits.

CONCLUSIONS

Winter navigation vessel traffic does increase the amount of material suspended in the river. If we take the amount of sediment settling in the "Rock Cut" area during periods of little vessel traffic (Figure 8), less than 1.5 milligrams per day, as the no vessel traffic condition, we can see as much as fifty fold increase in sediment due to vessel activity (Station E-18). This increase occurred during a winter which saw a minimum of

entrapment and reduced amount of heavy icebreaking activity.

Natural sedimentation may contribute as much or perhaps more inorganic sediment to the river during spring breakup.

It will be necessary to determine the effects of natural sedimentation on the coregonine eggs as well as the effect of vessel induced sedimentation. If the coregonine are more susceptable to sedimentation during early stages of egg development, then winter navigation may be a factor in mortality rates.

RECOMMENDATIONS

This study should be continued starting in the fall of 1979, and should run concurrently with the spawning ground study. Below is a further list of recommendations.

(1) Sampler design should be changed to include:

   a. More weight to keep samplers in place during times of increased current due to propeller wash or natural high water.

   b. A more positive control of the cover should be designed, this would include fender washers as a bearing for the cover and a steel spring to open the cover.

   c. Underwater buoy system as described above.

(2) Sampling should begin as soon after 1 November as spawning sites can be identified. At least four samplers are needed per site. Sampling should continue for a full year.

(3) Sampling should include water temperature, current recordings,

color, turbidity, conductivity and secchi disc readings.

(4) Core samples should be taken in reported spawning areas and analyzed for recent changes in annual sediment deposition.

Appendix I: United States Coast Guard Radio Log of Vessel Movement for March, 1979.

Date	Vessel	UB/DB*
3-7	Imperial St. Clair	UB
3-8	Imperial St. Clair	DB
3-10	A. M. Anderson	UB
3-11	Philip R. Clarke	UB
3-14	C. J. Calloway	DB
3-14	Roger Blough	DB
3-14	Imperial St. Clair	UB
3-14	C. J. Calloway	DB
3-18	Imperial St. Clair	DB
3-18	C. J. Calloway	DB
3-18	Roger Blough	UB
3-20	Imperial St. Clair	DB
3-21	Doan Transport	UB
3-21	A. M. Anderson	DB
3-21	Philip R. Clarke	DB
3-21	Imperial St. Clair	DB
3-23	Imperial St. Clair	UB
3-23	Doan Transport	DB
3-25	Imperial St. Clair	DB
3-26	Roger Blough	DB
3-26	C. J. Calloway	DB
3-27	Philip R. Clarke	UB
3-27	A. M. Anderson	UB
3-27	John G. Munson	UB
3-28	Imperial St. Clair	UB

*Upbound/Downbound

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